Steel
Industry of the Future

Fiscal Year 2004 Annual Report

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry
through improvements in energy and environmental performance

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Industrial Technologies Program — Boosting the Productivity and Competitiveness of U.S. Industry

Industry consumes 33 percent of all energy used in the United States. By developing and adopting more energy efficiency technologies, U.S. industry can boost its productivity and competitiveness while strengthening national energy security, improving the environment, and reducing emissions linked to global climate change.

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) works in partnership with U.S. industry to increase the efficiency of energy and materials use, both now and in the future. EERE's Industrial Technologies Program (ITP) is working to build the Industries of the Future through a coordinated program of research and development (R&D), validation, and dissemination of energy efficiency technologies and operating practices to reduce energy intensity in the industrial sector. ITP develops, manages, and implements a balanced portfolio that addresses industry requirements throughout the technology development cycle. The primary long-term strategy is to invest in high-risk, high-return R&D. Investments are focused on technologies and practices that provide clear public benefit but for which market barriers prevent adequate private sector investment.

ITP focuses its resources on a small number of energy-intensive materials and process industries that account for over 55 percent of industrial energy consumption.

- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Steel

ITP uses a leveraging strategy that maximizes the energy and environmental benefits of its process-specific technology investments by coordinating and cooperating with energy-intensive industries. By working closely with the private sector, the ITP is able to effectively plan and implement comprehensive R&D agendas and help disseminate and share best energy management practices throughout the United States. The ITP public-private partnerships also facilitate voluntary efforts, such as the President's Climate VISION initiative, to encourage industry and government to reduce greenhouse gas emissions.

ITP also conducts R&D projects on enabling technologies that are common to many industrial processes such as industrial energy systems, combustion, materials, and sensors and process control systems. In addition, ITP funds technical assistance activities to stimulate near-term adoption of best energy-saving technologies and practices within industry. These activities include plant assessments, tool development and training, information dissemination, and showcase demonstrations.

New technologies that use energy efficiently also lower emissions and improve productivity. By leveraging technical and financial resources of industry and government, the ITP partnerships have generated significant energy and environmental improvements that benefit the nation and America's businesses. Energy-intensive industries face enormous competitive pressures that make it difficult to make the necessary R&D investments in technology to ensure future efficiency gains. Without a sustained commitment by the private and public sectors to invest in new technology R&D and deployment, the ability to close the gap between U.S. energy supply and demand will be severely compromised.

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EXECUTIVE SUMMARY

Steel is one of the most energy-intensive industries in the United States. The steel industry is critical to the U.S. economy, providing the backbone for construction, transportation and manufacturing. In addition, steel has become the material of choice for a variety of consumer products. Traditionally valued for its strength, steel has also become one of the most recycled materials, with two-thirds of U.S. steel now produced from scrap.

Since the late 1990s, the U.S. steel industry has been hurt by large quantities of low-cost imports stemming from excess global steelmaking capacity and a collapse in Asian demand. This crisis has exacerbated the industry's existing problem of low profits and relatively low investment in research and development. Permanent technology changes, rather than short-term fixes, are needed to revolutionize the way energy is used in the manufacturing of iron and steel. Unfortunately, the industry is unable to support high-risk, long-term research on revolutionary technologies that could change the way steel is manufactured and greatly reduce its energy requirements.

Transformational R&D, such as that funded by the U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE), Industrial Technologies Program (ITP), is critical to maintaining the global competitive position of the U.S. steel industry. Studies sponsored by EERE have quantified the opportunity for saving energy in steelmaking (defined as the difference between today's energy use and the practical minimum energy use). DOE's goal in this area is to develop transformational technologies that will capture half of this opportunity by 2020, equivalent to a reduction in integrated steelmaking energy intensity of about 3 million Btu/ton.

A Successful Strategy with Industry

DOE's Office of Energy Efficiency and Renewable Energy leads federal development of advanced energy-efficient and environmentally-friendly industrial technologies. Steel industry R&D is a component of the overall EERE strategy, contributing to a reduction in energy intensity of industry, a goal outlined in the National Energy Policy.

EERE/ITP is working to build the Industries of the Future through a strategy that is based on multi-year planning, industry involvement and input during the planning process, and careful analysis and data based decision making. This strategy not only takes into consideration the interests of the industry as described in their R&D Technology Roadmaps, but also consists of an agenda of analytical studies that provide the basis for decision-making. For instance, the *Steel Industry Technology Roadmap*, published in 1998 and revised in December 2001, has provided the basis for focusing the R&D by identifying industry research interests. The Steel Energy and Environmental Profile, Bandwidth study, and Footprint study were developed using both government and industry data and information, and industry expertise to provide the next level of prioritization for the portfolio. By using these studies, the portfolio is able to design a multi-year R&D plan based on the focus area, barrier, and pathway approach. In this approach, a limited number of critical technology focus areas are identified along with the technical barriers preventing their successful implementation. A multi-year plan (called a "Pathway") is then developed that will guide the R&D activities leading to a successful development of the focus area technology. The "Pathways" are then the basis for solicitations of pre-competitive R&D that addresses both energy efficiency goals outlined in the National Energy Policy and steel industry research priorities. This successful strategy has now evolved to a point where it provides focus on potentially high-impact research to make revolutionary improvements in ironmaking and steelmaking.

Strong industry involvement ensures direct application of research results and testifies to the importance of this cost-shared research partnership. Both the American Iron and Steel Institute (AISI) and the Steel Manufacturers Association (SMA) participate in the development and implementation of the steel R&D portfolio. The AISI is also a major R&D partner and manages projects that address key priorities defined by the industry under their Technology Roadmap Program (TRP). Involving industry in the early R&D stages helps accelerate the development and application of energy efficiency technologies. The ITP Steel portfolio

also emphasizes university- and national laboratory-based research in order to tap into the technical resources of our nation's educational institutions and National Laboratory systems.

Achieving Energy Savings: Portfolio Strategy

DOE's portfolio of investments in steel processing R&D supports cost-shared, pre-competitive research addressing technological needs that have broad application throughout the steel industry. ITP has devised a strategy to foster both revolutionary ironmaking and steelmaking technologies and make incremental improvements to existing processes, thereby addressing long-term goals, as well as short-term needs. ITP also strives to expand the industry's fundamental base of knowledge to optimize key processes and resource efficiency.

ITP recently conducted, as noted previously, an energy bandwidth analysis that compared the practical minimum energy intensity of major steelmaking processes with energy intensity typical of today's processes. The results of this analysis are helping DOE identify the best opportunities for future R&D thrusts. As a result, DOE is now targeting high-risk, potentially high-impact opportunities for reducing the energy intensity of steel industry processes.

To facilitate this shift toward higher impact projects, the Steel portfolio is organized into three categories: Next Generation Steelmaking, Cokeless Ironmaking and Advanced Process Development. The Cokeless Ironmaking and Next Generation Steelmaking categories include several revolutionary technologies selected by DOE for development under its Ironmaking and Steelmaking Challenge solicitations issued several years ago. Projects within the Advanced Process Development category focus on improvements to conventional ironmaking, steelmaking, casting, forming, and fabrication technologies.

FY 2004 Highlights

- The pilot demonstration plant for the *Mesabi Nugget Ironmaking* project, part of an exciting, large-scale initiative to demonstrate the revolutionary ITmk3 ironmaking process, has completed four sustained operating tests. Construction on the first commercial unit is expected to begin in the spring of 2005 near Hoyt Lakes, Minnesota.

- An upgraded version of a *Hot-Strip Mill Model* that simulates hot-strip mill operations and predicts the steel's final mechanical properties has been developed by the INTEG Process Group, Inc. and is being used by a number of steel companies.

- In 2004, research continued on two projects that have been exploring innovative new ways to produce steel. *Novel Direct Steelmaking by Combining Microwave, Electric Arc, and Exothermal Heating Technologies* would eliminate the ironmaking step, while *Continuous Process to Melt, Refine and Cast Steel* would convert steel scrap into high-quality steel in one continuous process.

- Major progress continues to be made in developing materials to increase the *Pot Hardware Life on Steel Galvanizing Lines* by a factor of 10. More than 50 candidate materials and coatings have been tested for up to 6,000 hours, and two patents on new roll and bearing designs have been submitted.

- ISG-Bethlehem Steel continued long-term, successful operation of a set of 101 *Nickel-Aluminide Transfer Rolls* in its slab plate mill in Burns Harbor, Indiana. The new rolls have reduced the number of shutdowns related to roll blistering and have improved product quality, leading to significant cost and energy-savings.

- An *Automated Steel Cleanliness Analysis Tool* is being used at a number of steel mill test sites to evaluate such issues as steel castability, clogging, and the effect on inclusion content of adding "chill" scrap and late alloy additions.

- Michigan Technological University is leading an effort to develop and refine a technology that will *Increase the Value-added Utilization of Steelmaking Slag*. U.S. Steel has agreed to provide 500 tons of

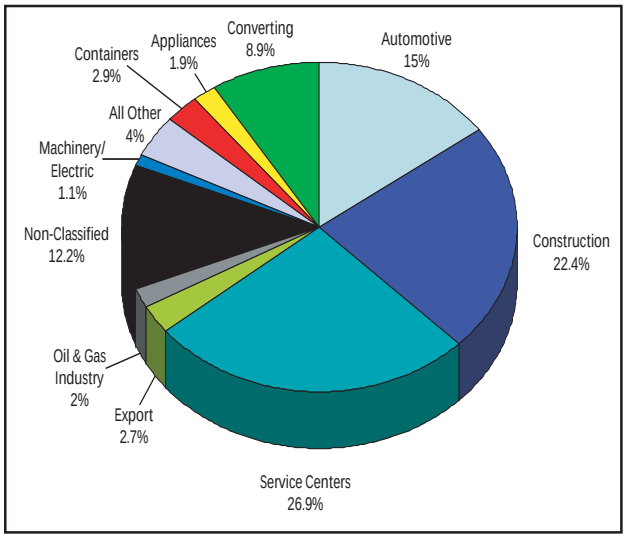
desulfurization slag from its Gary Works facility to the technology licensee's demonstration-site in Michigan to test the new process.

- ITP participated in a *two-day meeting focused on energy issues with SMA's Plant Operations Division in Durham, North Carolina*. More than 30 EAF mill operators learned about DOE-sponsored R&D projects and training, tools, and other energy management opportunities available from the office. The attendees were particularly interested in the new Mesabi cokeless ironmaking nugget technology described by Mesabi Nugget LLC.

- DOE and the American Iron and Steel Institute co-sponsored a series of *four training events* in Cleveland, Ohio in September 2004. These events were aimed at educating steel mill operators, demonstrating ways to improve the efficiency of their plant utility systems. The events covered fundamentals of compressed air systems, process heating equipment, pumping systems and steam systems.

INDUSTRY OVERVIEW

Exhibit 1
2003 Steel Shipments by Market Classification



Steel is an integral part of the U.S. infrastructure, providing the foundation for construction (bridges, buildings), transportation systems (railroads, cars, trucks) and utility systems (municipal water systems, power systems). It is also the material of choice for such diverse applications as military equipment, food storage, appliances and tools. Exhibit 1 displays the steel industry's market distribution.

The U.S. steel industry is a $50+ billion enterprise, and additional downstream processing pushes the value closer to $75 billion. The U.S. produced 103 million net tons of raw steel in 2003, nearly 10 percent of the total world steel production of 1.06 billion net tons. Large quantities of low-cost imports have challenged the industry in recent years, but restructuring, downsizing and widespread implementation of new technologies have led to vastly improved labor productivity, energy efficiency, and yields.

As a result of industry consolidation, the number of steelmaking facilities has decreased significantly over the last few decades. In 2002, 90 companies produced raw steel at almost 140 locations. The absolute number of integrated mills producing steel in basic oxygen furnaces has always been relatively small and is currently at around 20. The highest geographic concentration of mills is in the Great Lakes region, including Indiana, Illinois, Ohio, Pennsylvania, Michigan and New York. Approximately 80 percent of U.S. steelmaking capacity is in these states. The industry employs about 125,000 people nationwide.

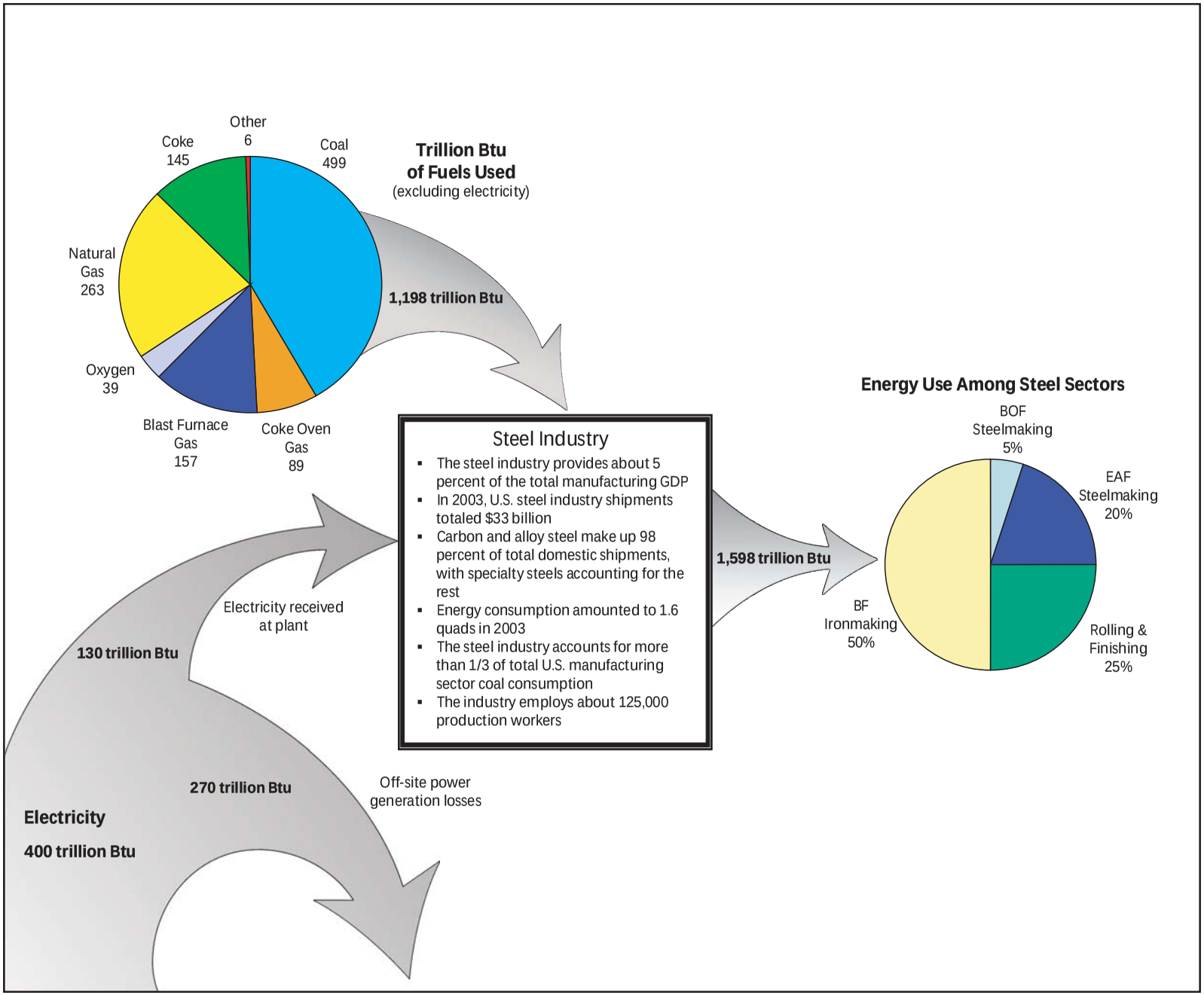
Energy Use in Steelmaking

Steel is produced via two different routes, both of which are energy-intensive. An integrated steel mill produces molten iron in blast furnaces using a form of coal known as coke, which is either produced onsite or purchased. This iron is used as a charge to produce steel in a basic oxygen furnace (BOF). An electric arc furnace steel producer, also known as a mini-mill, uses electric arc furnaces (EAFs) to produce steel from steel scrap and other iron-bearing materials. Over the past several decades, the balance of production has been shifting from integrated to EAF-based because of cost considerations and other factors. In 2003, integrated mills accounted for 49 percent of steel production in the U.S., while EAF mills accounted for 51 percent.

The U.S. steel industry consumed about 1.6 quadrillion Btu in 2003, and typically spends in excess of $4 billion per year on purchased fuels and electricity. As shown in Exhibit 2, electricity (and its associated generation and distribution losses) account for 25 percent of all energy used in the industry, with coal and other fossil and by-product fuels accounting for the other 75 percent. Coal and coke represent 40 percent of the industry's total energy consumption (or 55 percent of its fuel use). The by-product fuels – coke oven gas and blast furnace gas – represent another 16 percent of the industry's total energy consumption, or 20 percent of fuel use.

An analysis of steel industry energy use and losses reveals that about a quarter of the energy delivered to the plant is lost within the plant boundary prior to being used in specific processes. Process heating (including the blast furnace, steelmaking furnaces, reheat furnaces, other furnaces and boilers) represents the largest use of fuels in the steel industry (60 percent). Blast furnace ironmaking and electric arc furnace steelmaking are particularly energy-intensive, although the former relies mainly on coke, and the latter on electricity. Technologies that improve the efficiency of furnaces and other process heating systems have significant potential to reduce overall steel industry energy use.

Exhibit 2
Energy Use in the Steel Industry



THE CHALLENGE

The steel industry is one of the most energy-intensive industries in the U.S. manufacturing sector. A stable and dependable domestic source of steel is vital to America's economic and national security. However, the industry's financial and market woes in recent years have severely limited investment in research activities, emphasizing the need for public-private R&D collaboration.

Despite the domestic steel industry's modernization efforts of the past two decades, the industry has been struggling to survive. Between 2000 and 2003, high levels of imports caused many U.S. steel companies to declare bankruptcy (more than 30 during 2001 and 2002 alone). Because of the low-profit margins and high levels of foreign competition, the industry has been unable to conduct the high-risk, long-term technology R&D needed to ensure its survival in the 21st century.

In addition to economic issues, the steel industry faces major technological challenges in its bid to maintain international competitiveness, including:

- Making high-quality iron without coke,
- The high energy intensity associated with making steel via multiple inefficient processes, and
- Costly yield losses throughout the processing chain.

The competitive and financial demands facing steel companies have made them more willing to collaborate in strategic, pre-competitive areas to improve energy efficiency in iron and steel manufacturing processes. In its *Technology Roadmap*, the industry emphasizes the importance of collaborative partnerships involving government, industry, and academia in meeting the technology challenges of the future and accelerating the pace of technological innovation.

The Goal: Reducing Steelmaking Energy Intensity

The steel industry consumes between 1.6 and 2.0 quads (quadrillion, or 10^{15} Btu) of energy each year. The cost of purchasing this energy represents about 15 percent of the total manufacturing cost for steel, even higher for EAF steelmakers who rely heavily on electricity. The difference between the practical minimum energy requirement and actual requirements for energy-intensive unit operations of ironmaking and steelmaking are in the range of 20 to 30 percent (see Exhibit 3). DOE's goal is to develop technologies that will capture half of this opportunity by 2020, equivalent to a reduction in integrated steelmaking energy intensity of about 3 million Btu/ton.

R&D Pathways

The Industrial Technologies Program seeks to develop advanced technology for the domestic steel industry to help it survive in an environment of low profits and stiff foreign competition. A strong domestic steel industry with minimal reliance on imported raw materials and energy sources will help ensure national security.

The ITP Steel portfolio consists of cost-shared, pre-competitive research addressing technological needs that have broad application throughout the steel industry. All research projects are selected through a competitive review process. They must address priorities outlined in the *Steel Industry Technology Roadmap* and serve the EERE mission of increasing energy efficiency.

The Department of Energy's Steel portfolio has devised a strategy to foster both revolutionary ironmaking and steelmaking projects and make incremental improvements to existing processes, thereby addressing long-term goals while meeting short-term needs. Included in these activities are efforts to expand the industry's fundamental base of knowledge to optimize key processes and resource efficiency. Since 2001, there has been increased emphasis on revolutionary steelmaking concepts in order to maximize energy-savings. This shift in focus should produce dramatic reductions in steelmaking energy intensity over the long term.

The portfolio is organized into three major focus areas or pathways:

- Cokeless Ironmaking
- Next Generation Steelmaking
- Advanced Process Development

Exhibit 4 presents major opportunities or targets for each of these focus areas, and Exhibit 5 shows the corresponding research pathways identified by ITP.

One of the strengths of ITP's Steel portfolio is the comprehensive participation of industry and universities who provide both cost-share and in-kind support. The involvement of industry accelerates technology transfer and dissemination of research results. Industry partners represent the diversity of the steel industry and include integrated producers, EAF producers, suppliers, and end-users in several industries.

Exhibit 3
Steel Industry Energy Bandwidth

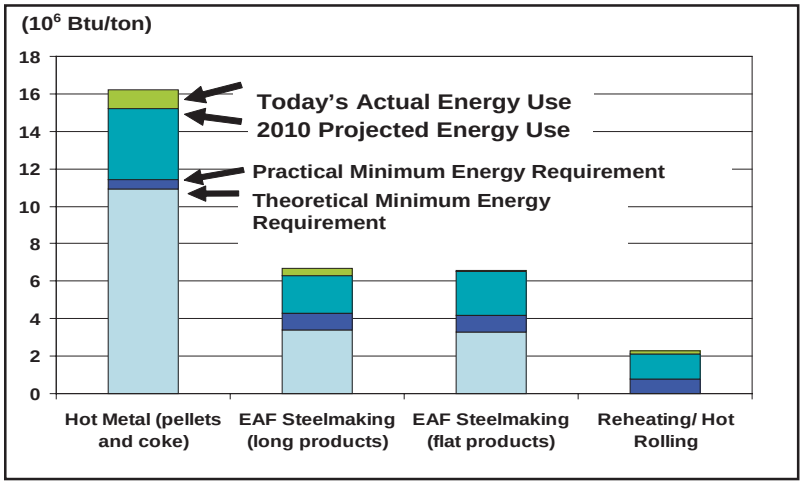


Exhibit 4
Steel Portfolio Targets

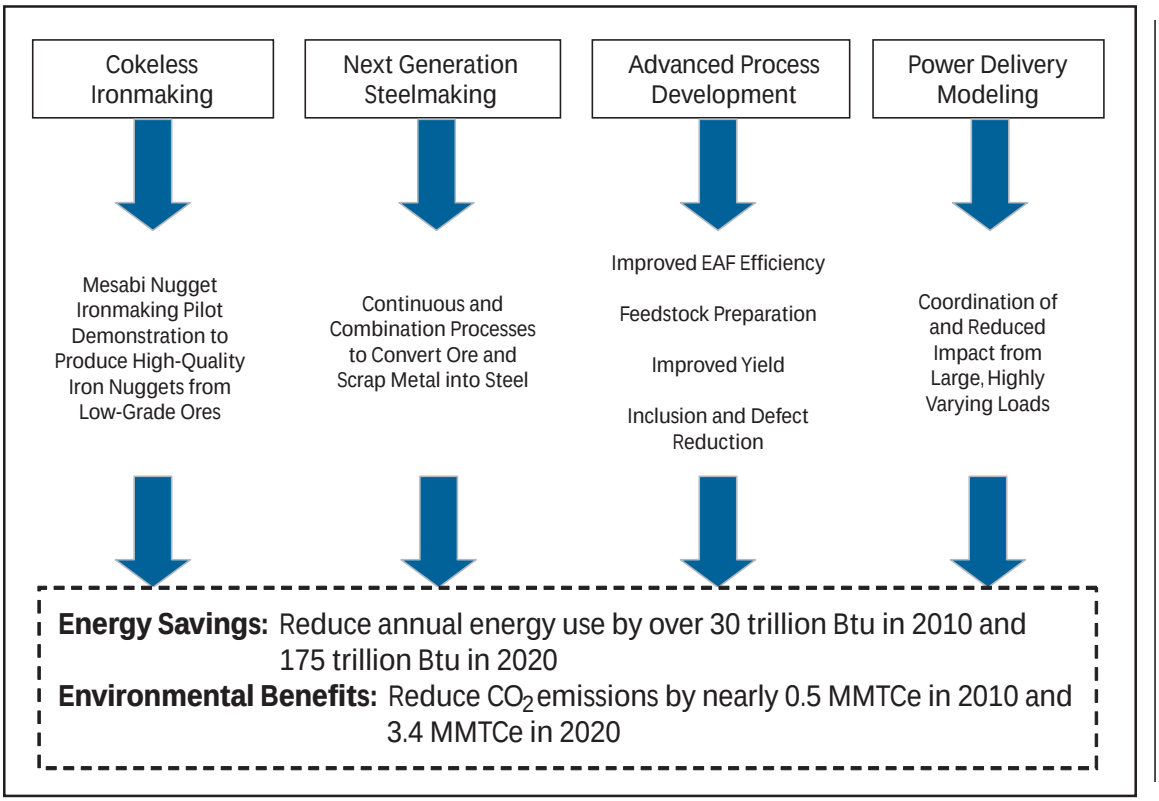


Exhibit 5
R&D Pathways for the Three Steel R&D Focus Areas

Steel Focus Area	R&D Pathways
Cokeless Ironmaking	Make iron with reductants other than coke, such as coal Evaluate ITmk3® process at pilot scale Test iron product in a commercial steelmaking facility
Next-Generation Steelmaking	Integrate iron and steelmaking production processes Develop processes that are less capital intensive Investigate novel combinations of existing technologies
Advanced Process Development	Improve the energy efficiency of hot processing steps Improve the yield of steel production processes Integrate technological advances into existing processes
Power Delivery Modeling	Develop short-term load forecasting and intelligent control of electric load dispatching that can be integrated with regional steel mill operators

FY 2004 HIGHLIGHTS AND ACCOMPLISHMENTS

In FY 2004, the Steel portfolio included nearly 40 projects, some of which were completed during that year (Exhibit 6). Exhibit 7 shows ongoing projects organized by the focus areas: Cokeless Ironmaking, Next Generation Steelmaking, and Advanced Process Development. In addition, nine projects relevant to the steel industry that are funded by other EERE program activities are shown in Exhibit 8.

In addition to sponsoring R&D, the Steel portfolio achieved a number of noteworthy accomplishments in 2004.

Exhibit 6
Steel Research Projects Completed in FY 2004

Advanced Process Development

- Optimization of Post Combustion in Steelmaking
- Intermetallics for the Steel Industry
- Large-Scale Evaluation of Nickel Aluminide Rolls in a Heat-Treat Furnace at the Burns Harbor Plant
- Development and Application of Steel Foam Materials and Structures
- Ultra-Low Carbon High-Strength Steels for Enhanced Stretch Formability and Dent Resistance
- Nitrogen Removal in EAF Steelmaking by Direct Reduced Iron Fines Injection
- In-Situ, Real-Time Measurement of Melt Constituents. Since it is not a Steel Project, it may be replaced by Quantifying Thermal Behavior of Slags.
- Clean Steels – Advancing the State-of-the-Art
- Validation of the Hot-Strip Mill Model
- Submerged Entry Nozzles that Resist Clogging (Plant Trials)

Exhibit 7
Active Steel Research Projects in FY 2004

Cokeless Ironmaking
- Mesabi Nugget Ironmaking

Next-Generation Steelmaking
- Development of a Process to Continuously Melt, Refine, and Cast High Quality Steel
- Novel Direct Steelmaking by Combining Microwave, Electric Arc, and Exothermal Heating Technologies

Advanced Process Development
- Automated Steel Cleanliness Analysis Tool
- Pulverized Coal Injection (PCI) Combustion Behavior in the Blast Furnace During PCI at High Rates
- Recycling and Reuse of BOF/BOP Steelmaking Slags
- Ladle Metallurgy and Casting
- Hydrogen and Nitrogen Control in Ladle and Casting Operations
- Inclusion Optimization for Next Generation Steel Products
- MAG-GATE System for Molten Metal Flow Control
- Controlled Thermal-Mechanical Processing of Tubes and Pipes
- Low-NOx Heating Alternative for Round Shapes, Steel Substrate (Strip), and Coil Box Transfer Bars
- Life Improvement of Pot Hardware in Continuous Hot Dipping Processes
- Constitutive Behavior of High-Strength Multiphase Sheet under High Strain Rate Deformation Conditions
- Development of Appropriate Resistance Spot Welding Practice for Advanced High-Strength Steels
- Novel Low-NOx Burners for Boilers in the Steel Industry
- Impact of Large, Highly Variable Loads
- Future Steelmaking Processes

Exhibit 8
Examples of Other EERE Projects Relevant to the Steel Industry

Combustion Projects
- Forced Internal Recirculation (FIR) Burner

Sensors and Controls Projects
- In-Situ, Real-Time Measurement of Melt Constituents in the Aluminum, Glass, and Steel Industries
- Tunable Diode Lasers Sensors for Monitoring and Control of Harsh Combustion Environments
- Advanced Wireless Sensors for the Industries of the Future
- Eaton Wireless Sensor Network for Advanced Energy Management Solutions
- Distributed Wireless Multisensor Technologies – A Novel Approach to Reducing Motor Energy Usage
- Wireless and Sensing Solutions Advancing Industrial Efficiency
- SQA: Surface Quality Assured Steel Bar Program

Small Business Innovation Research (SBIR) Grant Projects
- Fiber-Optic Sensor for Industrial Process Measurement and Control (Combustion)

Mesabi Nugget Ironmaking – The Mesabi nugget ironmaking project seeks to evaluate and refine the ITmk3 process developed by Kobe Steel, Ltd. The ITmk3 process is a new ironmaking technology that uses a rotary hearth furnace to transform iron ore fines and pulverized coal into iron nuggets of a similar quality to blast furnace pig iron. The direct use of coal to make iron is an alternative to the current ironmaking practice that uses coke made from coal. The high-quality, low-cost nuggets can be fed into either a basic oxygen furnace or an electric arc furnace. A pilot demonstration plant built by Mesabi Nugget, LLC in Silver Bay, Minnesota has completed multi-week trials to demonstrate continuous operation. In the four trials held since the spring of 2003, the plant generated nearly 10,000 tons of iron nuggets from Minnesota Mesabi range ore. The purpose of the project was to assess process conditions for producing iron nuggets that can be fed into a commercial steelmaking furnace. Construction on the first commercial nugget facility is expected to begin in Butler, Indiana in the spring of 2005. Additional facilities are expected to be constructed in Hoyt Lakes, Minnesota.

Novel Direct Steelmaking by Combining Microwave, Electric Arc, and Exothermal Heating Technologies – A novel direct steelmaking process combining multiple technologies continues to be evaluated by Michigan Technological University. Direct steelmaking eliminates the need for a separate ironmaking step, which could greatly reduce the energy intensity of the overall steelmaking process. The goal of the project is to develop a solid base of data on the technical, market, and economic potential of the process and to set targets for energy use, emissions, and costs. Combinations of raw materials are being tested with different heating methods to determine the effect on steel yield, carbon content, and exhaust gas emissions.

Development of a Process to Continuously Melt, Refine, and Cast High-Quality Steel - The University of Missouri-Rolla is developing a design for a new process that will convert steel scrap into high-quality steel in one continuous process. The new process will be less capital-and energy-intensive and more productive than conventional batch steelmaking processes. Efforts in FY 2004 included the development of fluid flow, mixing and heat transfer models; development of a thermodynamic model of the individual vessels used in the process; and initiation of melting experiments.

Future Steelmaking Processes – Carnegie Mellon University and U.S. Steel are examining the feasibility of using a combination of proven technologies to produce iron more efficiently with lower capital and operating costs. The goal is to develop a flexible fossil fuel-based process as an alternative to energy-intensive coke-based blast furnace ironmaking. During FY 2004, the project team continued to create energy and materials balance models for a number of existing smelting technologies combined with rotary hearth furnace technology. The models were then used to perform process optimization and perform process economic calculations. A final report is expected in early FY 2005.

Molten Metal Flow Control System – Precise control of the flow of molten steel at 3000 degrees Fahrenheit is difficult, but critical for quality control in casting. The Concept Engineering Group, Inc. has developed an electromagnetic valve that was designed and built to control the flow of molten metal; the system has been successfully tested in industrial applications. A market research study has identified 18 prospective casting operators interested in the technology. These findings were included in a commercialization plan prepared in FY 2004.

During an 18-month period, the rolls have been successfully used during the processing of more than 300 million pounds of steel. The new rolls are stronger and more temperature-resistant than traditionally-used alloys, and their enhanced properties are leading to vastly improved furnace system operations. Benefits have included elimination of more than 50 furnace shut-downs (~150 days; over 30 percent increase in up-time) over the last 18 months; higher yield and increased product quality of steel; 35 percent increase in energy efficiency; and lower operating and maintenance costs. This is a cooperative project by three areas of ITP: the Steel portfolio, Technology Delivery and Industrial Materials for the Future.

Hot-Strip Mill Model – A hot-strip mill model that simulates steel being processed in a hot-strip mill and predicts its final mechanical properties, originally developed by the University of British Columbia, has been upgraded and validated by INTEG Process Group. Enhancements in FY 2004 include the addition of Grade Builder, which allows users to develop and add new grades of steel. A detailed microstructure manual was also developed as a result of this addition. The latest version of the model is being used by a group of steel companies that participated in the validation effort, and has also been licensed to additional companies.

Pot Hardware Life for Galvanizing Lines – Major progress continues to be made in developing materials to increase the life of molten zinc pot hardware on steel galvanizing lines by a factor of 10. Interest in this project is great because these high-speed hot-dip lines often experience catastrophic component failures requiring shutdown of the line. Steel industry hot-dip operators are collaborating with researchers from West Virginia University Research, Oak Ridge National Laboratory, and materials suppliers on testing of components made from the new materials.

Recycling and Reuse of BOF/BOP Steelmaking Slags – Michigan Technological University is leading an effort to develop and refine a technology that will increase the value-added utilization of steelmaking slag. In FY 2004, U.S. Steel agreed to provide 500 tons of desulfurization slag from its Gary Works facility to the technology licensee's demonstration site in Michigan. The new technology will demonstrate its ability to process the slag on a 5 to 10 ton/hour basis.

Enhancing the Operation of Highly Varying Industry Loads to Increase Electricity Reliability, Quality, and Economics – The random nature and size of the electric loads associated with the operation of electric arc furnaces, rolling mills and large motors can cause large frequency deviations on the electricity grid. Oak Ridge National Laboratory is investigating the concept for handling highly varying loads while enhancing electric power reliability and quality. The concept comprises a number of load-forecasting and coordination techniques that can be applied in a particular utility control area. The results of this project may have application well beyond the steel industry and should yield economic and operational benefits.

Partnership Highlights

Steel Manufacturers Association (SMA) Meeting – In March 2004, ITP participated in a two-day meeting of SMA's Plant Operations Division in Durham, North Carolina focusing on energy issues. More than 30 EAF mill operators from around the country discussed ways to improve mill energy efficiency and listened to presentations about DOE-sponsored R&D projects and training, tools and other energy management opportunities available from the office. The attendees were particularly enthusiastic about the new Mesabi cokeless ironmaking technology described by Mesabi Nugget, LLC.

Student Fellowship Program – The Steel Manufacturers Association (SMA), in cooperation with steel companies and the DOE/EERE, has completed a cooperative education program for selected college students. Students were selected on the basis of knowledge, experience, desire and initiative. The sponsoring company submits details for a potential student project. At the conclusion of the work effort, SMA-DOE Fellows and industry-mentors provide a joint critique for the purpose of determining the success of the study program and measuring student interest in the steel industry.

Steel Industry Medal – The Board of Directors of the American Iron and Steel Institute (AISI) awarded the 2003 AISI Medal for the best steel industry technical paper to Dr. Scott Story (U.S. Steel), Dr. Mike Potter (R.J. Lee Group Inc.) and Dr. Richard Fruehan (Carnegie Mellon University) for their paper entitled "Inclusion

Analysis to Predict Casting Behavior." The paper resulted from research performed under an ITP financial assistance contract (DOE share $1.492 million) with R.J. Lee on computer controlled electron microscopic inspection of steel. The purpose of this work is to develop technology to improve the yield of quality steel. The AISI Medal is awarded annually to the one technical paper that demonstrates special merit and the most significance to the activities and interest of the iron and steel industry.

Improving Energy Efficiency Today

Technology Delivery – EERE/ITP's Technology Delivery activities offer products and services to assist industry in saving energy in the near-term. These products and services include software tools and associated training to improve the efficiency of plant utility systems, cost-shared plant assessments, no-cost plant audits for small-and mid-size companies, and numerous helpful publications describing applications of good plant-operating practices. Activities such as these have the potential to save the steel industry millions of dollars annually. To learn more, please visit: http://www.oit.doe.gov/bestpractices. For more information on the no-cost audits, visit: http://www.oit.doe.gov/iac.

Energy Management Training – DOE and the American Iron and Steel Institute have co-sponsored a series of four training events in Cleveland in September 2004 aimed at educating steel mill operators and demonstrating ways to improve the efficiency of their plant utility systems. The events covered fundamentals of compressed air systems, process heating equipment, pumping systems, and steam systems.

Plant-Wide Assessments (PWAs) – PWAs are cost-shared assessments of plant utility and process-related energy efficiency opportunities across a plant. Plants are selected through a competitive solicitation. Based on the experience of other manufacturers, each steel mill performing a PWA can expect to cut energy costs by a possible $1 million to $10 million per year. PWAs conducted in 2003 at two steel mills (North Star Steel in Wilton, Iowa and Weirton Steel in Weirton, West Virginia) identified potential annual savings in excess of $2.6 million and $1.3 million, respectively, in FY 2004.

Disseminating Research Results to Industry

ITP Web site – The ITP Web site (http://www.eere.energy.gov/industry/steel) is a valuable tool for disseminating information on the ITP's steel activities. The recently redesigned Web site highlights steel industry R&D activities, provides access to EERE publications, and notes upcoming solicitations. The Web site also contains a "News" section that provides articles on recent events, updates on research successes and notification about new software tools and other services of potential interest to the steel industry.

Steel Newsletter – ITP distributes an electronic newsletter to more than seven hundred steel industry personnel and other stakeholders in DOE research aimed at the steel industry. The *Steel Industry News from the Industrial Technologies Program at DOE* newsletter highlights recent accomplishments and milestones of Steel R&D projects.

Technical Papers and Articles – The plant-wide assessment conducted at North Star Steel in Wilton, Iowa was the subject of an article in the Winter 2004 edition of *Energy Matters*. The article discussed the benefits accrued at the Wilton plant as a result of implementing the changes recommended in the assessment, noting that North Star's parent company, Cargill, had embarked on a corporate-wide initiative to reduce waste and energy. The article described in detail the recommendations for improving the efficiency of the Wilton plant's electric arc furnace and rolling mill bill reheat furnace.

Energy Analysis – Targeting Energy Efficiency

Energy Bandwidth Study – An energy "bandwidth" showing the magnitude of energy-savings possible for each major steelmaking process was created using data from the Fruehan and Stubbles studies completed in previous years. A draft report documenting the bandwidth analysis and detailing the results was prepared in FY 2004. The bandwidth is being used to provide a rationale for supporting R&D on revolutionary new technologies with the highest potential impact on industry energy consumption.

Energy Footprint Study – ITP has developed an energy footprint study of the U.S. steel industry showing the energy flow and losses for energy supply, central energy-generation/utilities, energy distribution, energy conversion, and process energy use. Use and losses are shown for each process heating operation and for the various motor-driven systems. The goal of this study, which continued in FY 2004, is to provide a baseline of energy consumption and loss data for each major operation in the steel industry. The magnitude of the energy losses can provide guidance to the program on areas of R&D opportunity.

Critical Metrics Analysis – In FY 2004, ITP established key technical metrics for the Steel portfolio against which it can measure technical progress toward program goals. Although increased energy efficiency is understood to be the aim of all R&D sponsored by the program, additional metrics are needed to reflect the technical and scientific goals of the four R&D focus areas. For the Cokeless Ironmaking focus area, for example, the key metric was determined to be nugget purity (the percent of iron in the nugget), which is critical to this product's applicability in steelmaking furnaces. The analysis included determining the current baseline value for each metric, setting a goal, and identifying research pathways to achieve the goal.

TOOLS, PUBLICATIONS, AND RESOURCES AVAILABLE

EERE offers valuable tools and publications to help steel companies improve productivity and energy efficiency. Some of these resources are described below. Visit the Web site at http://www.eere.energy.gov/industry/steel/ for a complete listing.

Steel Industry Technology Roadmap – The *Steel Industry Technology Roadmap* represents an industry-defined, long-term agenda of research and development. As a public document, the roadmap provides a clear indication to both government and the private-sector of the desired directions to be followed in future steel related research. The roadmap was updated in FY 2001 in response to technological advances, changes in the global market, and new technical insights. To learn more, please visit: http://www.eere.energy.gov/industry/steel/roadmap.html.

Fact Sheets and Success Stories – Publications describing ongoing R&D projects, emerging technologies and commercial successes are available on the Web site at: http://www.eere.energy.gov/industry/steel/portfolio.html and http://www.eere.energy.gov/industry/steel/success.html.

Cost Reduction Now Brochures – A series of brochures on motors, steam systems, compressed air systems, pump systems, process heating and other topics can help companies recognize low-cost and quick-payback energy-saving opportunities. To learn more, please visit: http://www.eere.energy.gov/industry/steel/tools.html.

Energy and Environmental Profile of the U.S. Iron and Steel Industry – The profile, part of an industry series, benchmarks the energy and environmental characteristics of major unit operations in the steel industry. To learn more, please visit: http://www.eere.energy.gov/industry/steel/pdfs/steel_profile.pdf.

Theoretical Minimum Energies to Produce Steel for Selected Conditions – DOE-sponsored research has determined the theoretical minimum energy requirements for producing steel from ore, scrap and direct reduced iron. Dr. Richard Fruehan's report, *Theoretical Minimum Energies to Produce Steel for Selected Conditions*, provides insight into the potential energy savings (and associated reductions in carbon dioxide emissions) for ironmaking, steelmaking, and rolling processes. To view this report, please visit: http://www.eere.energy.gov/industry/steel/pdfs/theoretical_minimum_energies.pdf.

Energy Use in the U.S. Steel Industry: A Historical Perspective and Future Opportunities – Renowned industry expert Dr. John Stubbles has projected the U.S. steel industry's potential energy savings over the next 10 years. The report examines the potential impacts of state-of-the-art technologies and operating practices, as well as structural changes in the industry itself. To view the report, please visit: http://www.eere.energy.gov/industry/steel/pdfs/steel_energy_use.pdf.

Ironmaking Process Alternatives Screening Study – This study evaluates and compares a number of alternative ironmaking processes – some already proven and some under development – that will feed iron units to current and future steelmaking processes. To view the report, please visit: http://www.eere.energy.gov/industry/steel/pdfs/ironmaking_process.pdf.

HOW TO GET INVOLVED AND CONTACT INFORMATION

Partnership Information

Public-private partnerships are the foundation of ITP's technology delivery strategy. ITP includes its partners in every phase of the technology development process to focus scarce resources where they can have the greatest impact on industrial energy efficiency. To learn more, please visit our Web site at http://www.eere.energy.gov/industry.

- Collaborative, cost-shared research and development projects are a central part of ITP's strategy. Annual solicitations provide technology development opportunities in a variety of energy-intensive industries.

- Industries of the Future Partnerships increase energy efficiency in the most energy-intensive industries. In addition to cost-shared research and development projects, industry partners participate in the development of vision and roadmap documents that define long-term goals, technology challenges, and research priorities.

- Allied Partnerships provide an opportunity for ITP to reach a broad audience of potential customers by allying with corporations, trade associations, equipment manufacturers, utilities, and other stakeholders to distribute industrial energy efficiency products and services. By becoming an Allied Partner, an organization can increase its value to clients by helping them achieve plant efficiencies.

- State energy organizations work with ITP in applying technology to assist their local industries. ITP assists states in developing partnerships to mobilize local industries and other stakeholders to improve energy efficiency through best practices, energy assessments, and collaborative research and development.

- EERE's technical programs (of which ITP is one of eleven) give manufacturers access to a diverse portfolio of energy efficiency and renewable energy technologies and bring advanced manufacturing technology to the renewable energy community. For more information, access the EERE home page at http://www.eere.energy.gov.

- The President's Climate VISION (Voluntary Innovative Sector Initiatives: Opportunities Now) effort also offers opportunities for manufacturers to pursue cost-effective actions that will reduce greenhouse gas emissions. See http://www.climatevision.gov for details.

Access to Resources and Expertise

The Industrial Technologies Program provides manufacturers with a wide variety of industrial energy efficiency resources to help your company cut energy use right away. Visit our site at http://www.eere.energy.gov/ industry or call the EERE Information Center at 877-337-3463 to access these resources and for more information.

- ITP offers energy management best practices to improve energy efficiency throughout plant operations. Improvements to industrial systems such as compressed air, motors, process heat, and steam can yield enormous savings with little or no capital investment.

- Our suite of powerful system optimization software tools can help plants identify and analyze energy-saving opportunities in a variety of systems.

- Training sessions are held several times per year at sites across the country for companies interested in implementing energy-saving projects in their facilities. DOE software tools are used as part of the training sessions.

- ITP's qualified industrial energy specialists will work with your plant personnel to identify savings opportunities and train staff in the use of ITP software tools.

- Our extensive library of publications gives companies the resources they need to achieve immediate energy savings.

- Plant-wide energy assessments are available to manufacturers of all sizes interested in cutting their energy use. Cost-shared solicitations are available each year for plant-wide energy assessments. In addition, no-cost, targeted assessments are provided to eligible facilities by teams of engineering faculty and students from 26 university-based Industrial Assessment Centers around the country.

- The DOE Regional Offices provide a nation-wide network of capabilities for implementing ITP's technology delivery strategy. Regional Offices are located in the Southeast, Northeast, Midwest, Central, Mid-Atlantic, and Western regions. Visit http://www.eere.energy.gov/rso.html for more information.

WHERE TO GO FOR MORE INFORMATION

Visit our Web site: http://www.eere.energy.gov/industry/steel

Learn about all EERE programs: http://www.eere.energy.gov

EERE Information Center answers questions on EERE's products, services and 11 technology programs, refers callers to the most appropriate EERE resources, and refers qualified callers to the appropriate expert networks. You may contact the EERE Information Center by calling 1-877-EERE-INF (1-877-337-3463) or by completing the form at this site: http://www.eere.energy.gov/informationcenter. A customer service specialist or energy expert at the EERE Information Center will respond to your inquiry.

For print copies of DOE, EERE and ITP Publications, contact the
Energy Efficiency and Renewable Energy Information Center
P.O. Box 43165
Olympia, WA 98504-3165
http://www.eere.energy.gov/informationcenter/

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and great energy independence for America. By investing in technology breakthroughs today, our nation can look forward to a more resilient economy and secure future.

Far-reaching technology changes will be essential to America's energy future. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a portfolio of energy technologies that will:

- Conserve energy in the residential, commercial, industrial, government, and transportation sectors
- Increase and diversify energy supply, with a focus on renewable domestic sources
- Upgrade our national energy infrastructure
- Facilitate the emergence of hydrogen technologies as a vital new "energy carrier"

The Opportunities

Biomass Program
Using domestic, plant-derived resources to meet our fuel, power, and chemical needs

Building Technologies Program
Homes, schools, and businesses that use less energy, cost less to operate, and ultimately, generate as much power as they use

Distributed Energy & Electric Reliability Program
A more reliable energy infrastructure and reduced need for new power plants

Federal Energy Management Program
Leading by example, saving energy and taxpayer dollars in federal facilities

FreedomCAR & Vehicle Technologies Program
Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle

Geothermal Technologies Program
Tapping the Earth's energy to meet our heat and power needs

Hydrogen, Fuel Cells & Infrastructure Technologies Program
Paving the way toward a hydrogen economy and net-zero carbon energy future

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance

Solar Energy Technology Program
Utilizing the sun's natural energy to generate electricity and provide water and space heating

Weatherization & Intergovernmental Program
Accelerating the use of today's best energy-efficient and renewable technologies in homes, communities, and business

Wind & Hydropower Technologies Program
Harnessing America's abundant natural resources for clean power generation

To learn more, visit www.eere.energy.gov

Steel Industry of the Future

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry

U.S. Department of Energy
Energy Efficiency and Renewable Energy

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